

CLAIMS

What is claimed is:

- 1        1.    A monitor that can detect a plurality of trace  
2 molecules, comprising:
  - 3        a housing with an ionizing chamber that is  
4 approximately at one atmosphere;  
5        a photoionizer that is coupled to said ionizing  
6 chamber;  
7        an electrospray ionizer coupled to said ionizing  
8 chamber;  
9        a switch that controls the operation of said  
10 photoionizer and said electrospray ionizer to control  
11 different modes of operation; and,  
12        a detector that is coupled to said ionizing chamber.
- 1        2.    The monitor of claim 1, wherein said electrospray  
2 ionizer includes a vaporizer.

1        3. The monitor of claim 1, further comprising a  
2 chemical ionizer coupled to said ionizing chamber and said  
3 switch.

1        4. The monitor of claim 3, wherein said chemical  
2 ionizer includes a vaporizer.

1        5. The monitor of claim 2, further comprising a vacuum  
2 interface coupled to said ionizing chamber and said  
3 detector, said vacuum interface having an entrance that is  
4 orthogonal to said electrospray ionizer vaporizer.

1        6. The monitor of claim 4, further comprising a vacuum  
2 interface coupled to said ionizing chamber and said  
3 detector, said vacuum interface having an entrance that is  
4 orthogonal to said electrospray ionizer vaporizer.

1        7. The monitor of claim 1, further comprising a  
2 processor that controls said switch.

3        8. The monitor of claim 1, wherein said switch  
4 operates in a mode where said electrospray ionizer and said  
5 photoionizer are sequentially activated.

1           9. The monitor of claim 1, wherein said switch  
2 operates in a mode where said electrospray ionizer and said  
3 photoionizer are simultaneously activated.

1           10. The monitor of claim 8, wherein said switch  
2 operates in a mode wherein said electrospray ionizer and  
3 said photoionizer each generates a positive ion, then each  
4 generates a negative ion.

1           11. The monitor of claim 8, wherein said switch  
2 operates in a mode wherein said electrospray ionizer and  
3 said photoionizer each generates pairs of positive and  
4 negative ions sequentially in time.

1           12. The monitor of claim 1, wherein said switch  
2 operates in a mode where said photoionizer is on and said  
3 electrospray ionizer is switched between on and off states.

1           13. The monitor of claim 1, wherein said switch  
2 operates in a mode wherein said electrospray ionizer is on

3 and said photoionizer is switched between on and off  
4 states.

1 14. The monitor of claim 1, wherein said electrospray  
2 ionizer and said photoionizer each have an electrode that  
3 is supplied a voltage from a same voltage source.

1 15. The monitor of claim 9, further comprising a  
2 chemical ionizer that is coupled to said switch and  
3 generates a positive ion sequentially with said  
4 electrospray ionizer and said photoionizer, and then  
5 generates a negative ion sequentially with said  
6 electrospray ionizer and said photoionizer.

1 16. The monitor of claim 10, further comprising a  
2 chemical ionizer that is coupled to said switch and  
3 generates a positive and negative ion pair sequentially  
4 with said electrospray ionizer and said photoionizer.

1 17. The monitor of claim 1, further comprising a valve  
2 that controls a flow of a sample through an inlet of said  
3 electrospray ionizer and an inlet of said photoionizer.

1        18. The monitor of claim 17, wherein said valve  
2 sequentially allows the sample to flow through said  
3 electrospray ionizer inlet and said photoionizer inlet.

1        19. The monitor of claim 17, wherein said valve  
2 simultaneously allows the sample to flow through said  
3 electrospray ionizer inlet and said photoionizer inlet.

1        20. The monitor of claim 17, wherein said valve  
2 creates different flow rates through said electrospray  
3 ionizer inlet and said photoionizer inlet.

1        21. A monitor that can detect a plurality of trace  
2 molecules, comprising:

3        a housing with an ionizing chamber that is  
4 approximately at one atmosphere;

5        a photoionizer that is coupled to said ionizing  
6 chamber;

7        an electrospray ionizer coupled to said ionizing  
8 chamber;

9 switch means for controlling the operation of said  
10 photoionizer and said electrospray ionizer to control  
11 different modes of operation; and,  
12 a detector that is coupled to said ionizing chamber.

1 22. The monitor of claim 21, wherein said electrospray  
2 ionizer includes a vaporizer.

1 23. The monitor of claim 21, further comprising a  
2 chemical ionizer coupled to said ionizing chamber and said  
3 switch means.

1 24. The monitor of claim 23, wherein said chemical  
2 ionizer includes a vaporizer.

1 25. The monitor of claim 22, further comprising a  
2 vacuum interface coupled to said ionizing chamber and said  
3 detector, said vacuum interface having an entrance that is  
4 orthogonal to said electrospray ionizer vaporizer.

1 26. The monitor of claim 24, further comprising a  
2 vacuum interface coupled to said ionizing chamber and said

3 detector, said vacuum interface having an entrance that is  
4 orthogonal relative to said electrospray ionizer vaporizer.

1 27. The monitor of claim 21, further comprising a  
2 processor that controls said switch means.

3 28. The monitor of claim 21, wherein said switch means  
4 operates in a mode where said electrospray ionizer and said  
5 photoionizer are sequentially activated.

1 29. The monitor of claim 21, said switch means  
2 operates in a mode where said electrospray ionizer and said  
3 photoionizer are simultaneously activated.

1 30. The monitor of claim 28, wherein said switch means  
2 operates in a mode wherein said electrospray ionizer and  
3 said photoionizer each generates a positive ion, then each  
4 generates a negative ion.

1 31. The monitor of claim 28, wherein said switch means  
2 operates in a mode wherein said electrospray ionizer and  
3 said photoionizer each generates pairs of positive and  
4 negative ions sequentially in time.

1        32. The monitor of claim 21, wherein said switch means  
2 operates in a mode where said photoionizer is on and said  
3 electrospray ionizer is switched between on and off states.

1        33. The monitor of claim 21, wherein said switch means  
2 operates in a mode wherein electrospray ionizer is on and  
3 said photoionizer is switched between on and off states.

1        34. The monitor of claim 21, wherein said electrospray  
2 ionizer and said photoionizer each have an electrode that  
3 is supplied a voltage from a same voltage source.

1        35. The monitor of claim 30, further comprising a  
2 chemical ionizer that is coupled to said switch means to  
3 generate a positive ion sequentially with said electrospray  
4 ionizer and said photoionizer, and then generates a  
5 negative ion sequentially with said electrospray ionizer  
6 and said photoionizer.

1        36. The monitor of claim 30, further comprising a  
2 chemical ionizer that is coupled to said switch means to



3 generate a positive and negative pair of ions sequentially  
4 with said electrospray ionizer and said photoionizer.

1 37. The monitor of claim 21, further comprising a  
2 valve that controls a flow of a sample through an inlet of  
3 said electrospray ionizer and an inlet of said  
4 photoionizer.

1 38. The monitor of claim 37, wherein said valve  
2 sequentially allows the sample to flow through said  
3 electrospray ionizer inlet and said photoionizer inlet.

1 39. The monitor of claim 37, wherein said valve  
2 simultaneously allows the sample to flow through said  
3 electrospray ionizer inlet and said photoionizer inlet.

1 40. The monitor of claim 37, wherein said valve  
2 creates different flowrates through said electrospray  
3 ionizer inlet and said photoionizer inlet.

1 41. A method for detecting a plurality of trace  
2 molecules, comprising:

3       ionizing a trace molecule with a photoionizer at  
4       approximately atmospheric pressure;  
5       ionizing a trace molecule with an electrospray ionizer  
6       at approximately atmospheric pressure;  
7       detecting the ionized trace molecules; and,  
8       switching a mode of operation of the photoionizer and  
9       the electrospray ionizer.

1       42. The method of claim 41, further comprising  
2       vaporizing a sample that contains the trace molecules.

1       43. The method of claim 41, further comprising  
2       ionizing a trace molecule with a chemical ionizer at  
3       approximately atmospheric pressure.

1       44. The method of claim 41, wherein the mode includes  
2       activating the electrospray ionizer and the photoionizer  
3       sequentially.

1       45. The method of claim 41, wherein the mode includes  
2       activating the electrospray ionizer and the photoionizer  
3       simultaneously.

1        46. The method of claim 44, wherein the mode includes  
2        activating the electrospray ionizer and the photoionizer so  
3        that each generates a positive ion, then each generates a  
4        negative ion.

1        47. The method of claim 44, wherein the mode includes  
2        activating the electrospray ionizer and the photoionizer so  
3        that each generates pairs of positive and negative ions  
4        sequentially in time.

1        48. The method of claim 41, wherein the mode includes  
2        maintaining the photoionizer on, while switching the  
3        electrospray ionizer between on and off states.

1        49. The method of claim 41, wherein the mode includes  
2        maintaining the electrospray ionizer on, while switching  
3        the photoionizer between on and off states.

1        50. The method of claim 44, further comprising  
2        ionizing a trace molecule with a chemical ionizer in a mode  
3        where the chemical ionizer generates a positive ion

4 sequentially with the electrospray ionizer and the  
5 photoionizer, and then generates a negative ion  
6 sequentially with the electrospray ionizer and the  
7 photoionizer.

1 51. The method of claim 44, further comprising  
2 ionizing a trace molecule with a chemical ionizer in a mode  
3 where the chemical ionizer generates a positive and  
4 negative ion pair sequentially with the electrospray  
5 ionizer and photoionizer.

1 52. The method of claim 41, wherein a sample with the  
2 trace molecules sequentially flows through an electrospray  
3 ionizer inlet and a photoionizer inlet.

1 53. The method of claim 41, wherein a sample with the  
2 trace molecules simultaneously flows through an  
3 electrospray ionizer inlet and a photoionizer inlet.

1 54. The method of claim 41, wherein a sample with the  
2 trace molecules flows through an electrospray ionizer inlet  
3 and a photoionizer inlet at different flow rates.

1        55. A monitor that can detect a trace molecule,  
2   comprising:  
3        a housing with an ionizing chamber that is  
4   approximately at one atmosphere;  
5        a vacuum interface that is coupled to said ionizing  
6   chamber through an entrance;  
7        an electrospray ionizer that is coupled to said  
8   ionizing chamber and has a vaporizer that is orthogonal to  
9   said vacuum interface entrance; and,  
10       a detector that is coupled to said vacuum interface.

1        56. The monitor of claim 55, further comprising a  
2   photoionizer coupled to said ionizing chamber.

1        57. The monitor of claim 55, further comprising a  
2   chemical ionizer that is coupled to said ionizing chamber  
3   and has a vaporizer that is orthogonal to said vacuum  
4   interface entrance.

1        58. The monitor of claim 55, further comprising a  
2   valve that controls a flow of a sample through an inlet of

3 said electrospray ionizer and an inlet of said  
4 photoionizer.

1 59. The monitor of claim 58, wherein said valve  
2 sequentially allows the sample to flow through said  
3 electrospray ionizer inlet and said photoionizer inlet.

1 60. The monitor of claim 58, wherein said valve  
2 simultaneously allows the sample to flow through said  
3 electrospray ionizer inlet and said photoionizer inlet.

1 61. The monitor of claim 58, wherein said valve  
2 creates different flow rates through said electrospray  
3 ionizer inlet and said photoionizer inlet.

1 62. A monitor that can detect a trace molecule,  
2 comprising:

3 a housing with an ionizing chamber that is  
4 approximately at one atmosphere;

5 a vacuum interface that is coupled to said ionizing  
6 chamber through an entrance;

7 a chemical ionizer that is coupled to said ionizing  
8 chamber and has a vaporizer that is orthogonal to said  
9 vacuum interface entrance; and,  
10 a detector that is coupled to said vacuum chamber.

1 63. The monitor of claim 62, further comprising a  
2 photoionizer coupled to said ionizing chamber.

1 64. A monitor that can detect a plurality of trace  
2 molecules, comprising:

3 a housing with an ionizing chamber that is  
4 approximately at one atmosphere;

5 a photoionizer that is coupled to said ionizing  
6 chamber;

7 a chemical ionizer coupled to said ionizing chamber;

8 a switch that controls the operation of said

9 photoionizer and said chemical ionizer to control different  
10 modes of operation; and,

11 a detector that is coupled to said ionizing chamber.

1 65. The monitor of claim 64, wherein said chemical  
2 ionizer includes a vaporizer.

3        66. The monitor of claim 65, further comprising a  
4 vacuum interface coupled to said ionizing chamber and said  
5 detector, said vacuum interface having an entrance that is  
6 orthogonal to said chemical ionizer vaporizer.

1        67. The monitor of claim 64, further comprising a  
2 processor that controls said switch.

3        68. The monitor of claim 64, wherein said switch  
4 operates in a mode where said chemical ionizer and said  
5 photoionizer are sequentially activated.

1        69. The monitor of claim 64, wherein said switch  
2 operates in a mode where said chemical ionizer and said  
3 photoionizer are simultaneously activated.

1        70. The monitor of claim 68, wherein said switch  
2 operates in a mode wherein said chemical ionizer and said  
3 photoionizer each generates a positive ion, then each  
4 generates a negative ion.

1        71. The monitor of claim 68, wherein said switch  
2 operates in a mode wherein said chemical ionizer and said



3 photoionizer each generates pairs of positive and negative  
4 ions sequentially in time.

1 72. The monitor of claim 64, wherein said switch  
2 operates in a mode where said photoionizer is on and said  
3 chemical ionizer is switched between on and off states.

1 73. The monitor of claim 64, wherein said switch  
2 operates in a mode wherein said chemical ionizer is on and  
3 said photoionizer is switched between on and off states.

1 74. A monitor that can detect a plurality of trace  
2 molecules, comprising:

3 a housing with an ionizing chamber that is  
4 approximately at one atmosphere;

5 a photoionizer that is coupled to said ionizing  
6 chamber;

7 a chemical ionizer coupled to said ionizing chamber;

8 switch means for controlling the operation of said  
9 photoionizer and said chemical ionizer to control different  
10 modes of operation; and,

11 a detector that is coupled to said ionizing chamber.

1        75. The monitor of claim 74, wherein said chemical  
2 ionizer includes a vaporizer.

1        76. The monitor of claim 74, further comprising a  
2 vacuum interface coupled to said ionizing chamber and said  
3 detector, said vacuum interface having an entrance that is  
4 orthogonal to said chemical ionizer vaporizer.

1        77. The monitor of claim 74, further comprising a  
2 processor that controls said switch means.

3        78. The monitor of claim 74, wherein said switch means  
4 operates in a mode where said chemical ionizer and said  
5 photoionizer are sequentially activated.

1        79. The monitor of claim 74, said switch means  
2 operates in a mode where said chemical ionizer and said  
3 photoionizer are simultaneously activated.

1        80. The monitor of claim 78, wherein said switch means  
2 operates in a mode wherein said chemical ionizer and said

3 photoionizer each generates a positive ion, then each  
4 generates a negative ion.

1 81. The monitor of claim 78, wherein said switch means  
2 operates in a mode wherein said chemical ionizer and said  
3 photoionizer each generates pairs of positive and negative  
4 ions sequentially in time.

1 82. The monitor of claim 74, wherein said switch means  
2 operates in a mode where said photoionizer is on and said  
3 chemical ionizer is switched between on and off states.

1 83. The monitor of claim 74, wherein said switch means  
2 operates in a mode wherein chemical ionizer is on and said  
3 photoionizer is switched between on and off states.

1 84. A method for detecting a plurality of trace  
2 molecules, comprising:

3 ionizing a trace molecule with a photoionizer at  
4 approximately atmospheric pressure;

5 ionizing a trace molecule with an chemical ionizer at  
6 approximately atmospheric pressure;

7 detecting the ionized trace molecules; and,  
8 switching a mode of operation of the photoionizer and  
9 the chemical ionizer.

1 85. The method of claim 84, further comprising  
2 vaporizing a sample that contains the trace molecules.

1 86. The method of claim 84, wherein the mode includes  
2 activating the chemical ionizer and the photoionizer  
3 sequentially.

1 87. The method of claim 84, wherein the mode includes  
2 activating the chemical ionizer and the photoionizer  
3 simultaneously.

1 88. The method of claim 86, wherein the mode includes  
2 activating the chemical ionizer and the photoionizer so  
3 that each generate a positive ion, then each generate a  
4 negative ion.

1 89. The method of claim 86, wherein the mode includes  
2 activating the chemical ionizer and the photoionizer so

3 that each generate pairs of positive and negative ions  
4 sequentially in time.

1 90. The method of claim 84, wherein the mode includes  
2 maintaining the photoionizer on, while switching the  
3 chemical ionizer between on and off states.

1 91. The method of claim 84, wherein the mode includes  
2 maintaining the chemical ionizer on, while switching the  
3 photoionizer between on and off states.